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STUDY ON PROVIDING TRAFFIC SAFETY INFORMATION SYSTEM USING MOBILE DEVICE

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ABSTRACT

As 90 percent of traffic accidents are caused by human factors, so it would be helpful to prevent traffic accidents if we provide warning signs to drivers pre-determining the movement of their vehicles. The sensor which measures the movement of a vehicle is able to use a mobile device owned by drivers, utilizing lots of measured data from the device, it is possible to establish appropriate warning providing system for an individual driver.

Therefore, this study aimed to provide a measure of giving suitable and customized warning information to individual drivers using mobile devices which are widely available around the world. While driving at 100km/h, The average acceleration during driving at all speeds was -0.052m/s^2 while the maximum acceleration -0.763m/s^2 was revealed while driving at 100km/h. Then, using the centroid derived in cluster analysis, a method of providing warning information was proposed. In addition, zigzag driving in one to three lanes was conducted to measure changes in angular velocities and a maximum 0.500 rad/s angular velocity was obtained.

KEYWORDS: Safe, Vehicle, GPS, Accelerometer, Gyroscope

INTRODUCTION

Although the number of traffic accidents in recent 10 years has decreased gradually, casualties and injuries due to traffic accident have continuously occurred. The cause of traffic accident can be divided into three: human factor (93%), road geometry factor (34%), and vehicle factor (13%). That is, a human factor is the highest factor of traffic accident. There are many human factors in traffic accident. Among them, speed, drowsiness, and driving under the influence are the most frequent occurrence in traffic accident. To reduce such traffic accident due to human factors, it is necessary to provide appropriate warning information to individual drivers.

Currently, fixed structures such as road safety signs or mobile structures such as VMS (Variable Message Signs) are employed as a way to provide warning information to drivers. However, such traffic infrastructures have limitations to provide customized information to individual drivers. Therefore, this study aimed to provide a measure of giving suitable and customized warning information to individual drivers using mobile devices which are widely available around the world.

In this study, zigzag driving, which is due to drowsiness and driving under the influence, and rapid deceleration, which is due to unexpected situation during driving, were represented as dangerous driving situations to implement danger situations due to human factors. In addition, location, velocity, acceleration, and angular velocity information were acquired using a gyroscope, an accelerometer and a Global Positioning System (GPS) which are built in mobile devices and changes in sensor values obtained according to dangerous driving situations were analyzed. The results obtained through this study can contribute to providing traffic safety services using mobile devices in the future.

LITERATURE REVIEW

In this section, previous studies about analysis of driving patterns using a sensor that can measure driver's movements and providing warning information to users are discussed.

Garber and and Gadiraju (2005) studied a relationship between ASI (Acceleration Severity Index) threshold and severity of traffic accident using an EDR (Event Data Recorder), which records vehicle speeds and brake conditions prior to the accident and during the time of accident. The analysis results showed that Longitudinal ASI was appropriate to be used as a predictor of injury level and suggested an effective threshold value. Hhu et al.(2010) proposed a detection method of behavioral patterns of violent drivers based on distance scaling of obtained feature vector values which were calculated by applying a feature matrix to data values acquired using acceleration components in the X and Y axes of the three-axis acceleration sensor. This method achieved 80%accuracy of driver's behavior patterns verified through experiments. Ko et al. (2010) conducted research that can assess traffic flow using an acceleration noise which was defined as standard deviation of acceleration. In addition, they considered the acceleration noise to be able to reflect interaction among vehicle/driver, road, and traffic in traffic flows and set this as potential traffic flow indicators. They also analyzed the correlation of driver/vehicle characteristics with acceleration noise measured using GPSs installed in four highways. The analysis results showed that acceleration noise was affected by the characteristic of vehicle and driver as well as condition of traffic flow (Level of Service). Oh et al. (2009) proposed a warning information system that can induce driver's avoidance behavior efficiently by detecting dangerous traffic situation that may cause traffic accident in real time driving environments and providing warning information. In addition, he developed information processing and its technique to implement the proposed system by deriving Surrogate Safety Measures. Oh et al. (2009) provided a safe driving management system consisting of digital driving recorder and black box, which is upgradable, and developed a threshold that can analyze a dangerous driving level of drivers and verified the significance level of the derived threshold. Song et al. (2012) proposed a method of how to record sensor data during driving and recognize driving patterns using smartphones. He recognized driving patterns by applying determination methods using the DTW (Dynamic Time Warping) algorithm and based on this result, conducted research for the purpose of recording driving information and providing information. Yeom et al. (2009) proposed a positioning system in which a GPS and an accelerometer were integrated to acquire continuous navigation information. He removed vibration and noise components of an accelerometer suing the Kalman filter and proposed a positioning system in which a GPS and accelerometer were integrated as a result of experiments.

Preparation of Data Collection and Analysis

In this study, a situation of dangerous driving was categorized into rapid deceleration and zigzag driving and dangerous events according to two situations were generated to collect changes in data due to the dangerous situation. Rapid deceleration means rapid reduction of vehicle speed due to emergency situation occurrence in front of the driving in the vehicle driving direction. Zigzag driving is a driving pattern of repetitive right and left movement of vehicle in a short time in the moving direction, which is not intentional by drivers such as lane change but is due to driving under the influence and drowsiness.

Section for Analysis

In this study, a section for analysis was set to an uninterrupted flow in National Highway No. 77, Jangsan-Gajwa

Interchange to Hanryu-World Interchange, which was about 6km-long one way. This section was an one way three-lane road mixed with straight and curve sections including entry and exit ramps. The speed limit in this area was 80km/h. This section was chosen for the analysis section because it was recently open so its road condition had no influence on changes in vehicle speed freely. Figure 1 shows the section.

Figure 1: Section for Analysis

Data Collection Method

As shown in Figure 2(L), a mobile device was installed in the vehicle to determine a driving pattern of drivers using mobile devices. The mobile device can obtain driving information such as acceleration and angular velocity in three axes (x-axis, y-axis, and z-axis) in every 0.1 second. In this study, acceleration in the Z-axis direction and angular velocity in the X-axis direction, which were based on the axis of the mobile device installed in the vehicle, were used as shown in Figure 2(R). An acceleration sensor converts acceleration components generated by gravity and motion into electric signals while an angular velocity sensor measures angular displacement per unit time, which is appropriate to measure motion and direction of humans.

Figure 2: Location (L) and Axis (R) for Mobile Device

To identify dangerous driving situations (rapid deceleration or zigzag driving), an observation through the sensor is required while driving without changes in speed. A speed limit in the analysis section was 80km/h and changes in acceleration and angular velocity were analyzed while driving at a constant speed of 60km/h, 80km/h, and 100km/h respectively. Deceleration was measured by decelerating a vehicle speed arbitrarily during the constant speed driving while changes in values of the sensor were measured during zigzag driving by changing a driving lane arbitrarily.

ANALYSIS RESULTS

Analysis of Vehicle Driving at a Constant Speed

Table 1. shows descriptive statistics of acceleration while driving at a speed of 60km/h, 80km/h, and 100km/h. The average acceleration during driving at all speeds was -0.052m/s^2 while the maximum acceleration -0.763m/s^2 was

revealed while driving at 100km/h.

Table 1: Description for Acceleration

		60kph	80kph	100kph	avg.
Average		-0.051	-0.050	-0.056	-0.052
Variance		0.004	0.005	0.008	0.006
Minimum		-0.461	-0.726	-0.763	-0.650
Maximum		0.549	0.409	0.460	0.473
Percentile	5	-0.148	-0.159	-0.196	-0.168
	95	0.047	0.063	0.070	0.060

Analysis of Rapid Deceleration Driving

While driving at 100km/h without speed change, driving speed was decelerated by more than 20km/h to analyze a threshold value that can provide danger information. In the analysis section, more than 10 times of arbitrary rapid deceleration were done and changes in acceleration due to the reduced speed were shown in Figure 3.

Figure 3: Variation of Acceleration

In addition, the centroid of danger section that can be determination criteria was derived through K-means clustering. The result was derived while the number of clusters was set to 2, 3, and 4. To provide warning information, an average between centroids derived from the clusters is derived and can be set to a threshold that provides warning information. When the number of clusters was two, three, and four, one, two, and three thresholds can be derived respectively.

Table 2: Analysis Result for Clustering

# of Cluster	Centroid	# of Cluster	Centroid	# of Cluster	Centroid
2	-0.0258	3	0.0248	4	0.0570
			-0.1051		-0.0355
	-0.4501				-0.1450
			-0.5017		-0.5052

Analysis of the Results while Zigzag Driving

An experimental driving imitated a zigzag driving pattern to conduct basic research on zigzag driving due to drowsiness or driving under the influence. Zigzag driving was divided into four cases: Normal, which drove normally along the lane without changing the lane, #1 lane, which was zigzag driving in a single lane, #2 lane, which was zigzag driving in two lanes, and #3 lane, which was zigzag driving in three lanes. Table 3. and Figure 4. show the measured values

and changes according to each driving.

Table 3: Description for Angular Velocity

		Normal	#1 Lane	#2 Lane	#3 Lane
Average		-0.004	0.011	0.002	-0.001
Variance		0.003	0.005	0.007	0.009
Min		-0.517	-0.256	-0.368	-0.456
Max		0.371	0.310	0.389	0.500
Percentile	10	-0.060	-0.074	-0.107	-0.112
	15	-0.048	-0.058	-0.081	-0.092
	85	0.040	0.077	0.083	0.082
	90	0.050	0.096	0.104	0.110

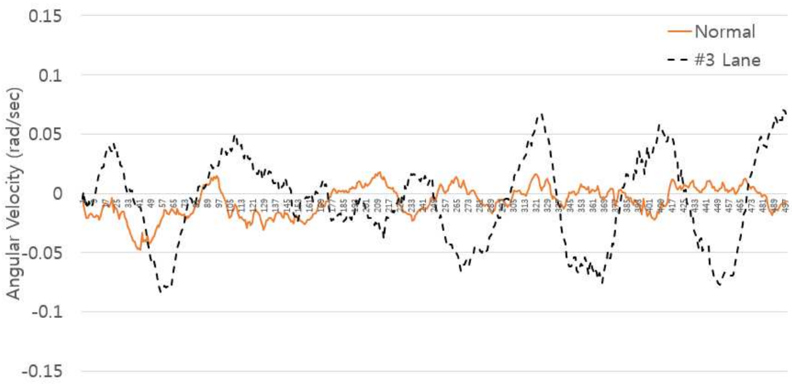

Figure 4: Variation of Angular Velocity

The result was analyzed that changes in angular velocities showed that the larger the changes in lanes were, the larger the variance and percentile values were. During the normal driving, variance was 0.003 while it was 0.009 during the zigzag driving in three lanes. When values in 90 percentile were compared, it became large from 0.050 to 0.110. However, in the case of average, pattern changes were not found according to changes in lanes, which was because outliers were reflected in the result. Therefore, danger information can be provided to drivers if an angular velocity was deviated from a range of 10 percentile to 90 percentile revealed while the normal driving was done.

CONCLUSIONS

The present study analyzed rapid deceleration and zigzag driving patterns using acceleration and angular velocities collected at mobile devices to provide danger and warning information to drivers. While driving at 100km/h, The average acceleration during driving at all speeds was $-0.052 m/s^2$ while the maximum acceleration $-0.763 m/s^2$ was revealed while driving at 100km/h. Then, using the centroid derived in cluster analysis, a method of providing warning information was proposed. In addition, zigzag driving in one to three lanes was conducted to measure changes in angular velocities and a maximum 0.500 rad/s angular velocity was obtained.

Furthermore, this study proposed a measure to provide danger information to drivers if an angular velocity was deviated from a range of 10 percentile to 90 percentile revealed while the normal driving was done. The following future

research is needed to develop the current study further. First, additional data collection in consideration of gender and age is required while data collection including a variety of analysis sections is also needed. Moreover, as a method of providing warning information, a field test is required to provide a measure of warning information to users in consideration of driver's response time. It is expected that the study result will be utilized as foundational research that can provide services employed by a large number of drivers without additional device installation and safe traffic services using mobile devices.

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